UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service

PRELIMINARY REPORT OF COTTON SPINNING AND RELATED FIBER STUDIES, IN CONNECTION WITH THE REGIONAL VARIETY SERIES, CROPS OF 1935 AND 1936 1/

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INTRODUCTION

The regional variety studies of cotton have constituted an important section of the cotton quality investigations conducted by the U. S. Department of Agriculture during the last few years. Because the broad background and general plan of this work have been presented and discussed in previous papers on this program, they do not need to be repeated here. A few words regarding the purpose and objectives of the fiber and spinning tests, together with a simple description of the plan of these tests, should give all that is required in the way of a setting for the presentation of the results.

The analyses of these samples are expected to provide information along three rather distinct but closely related lines. First, they will furnish comparable data on the manufacturing quality of 16 well-known varieties of American cotton. Second, they will yield data of a type, range, and quantity not heretofore available concerning the precise influence of fiber properties on yarn quality. Third, they will provide information as to the influence of variety, location and season upon the different fiber properties measured and upon the various factors that go to make up spinning quality.

In addition to these objectives may be listed a fourth and, in many respects, no less important result of these tests. They will provide better and more complete "bench-marks" of fiber and spinning quality than are now available. These will be particularly useful in evaluating varieties of American cotton not yet tested, new varieties or strains developed by breeders, samples of cotton of foreign growth, and the like.

This paper is a brief progress report of the work done so far. In it are presented and discussed the more obvious and important findings of the tests at the two-thirds mark. The presentation relates only to the first two objectives listed above, namely, the influence of variety, location, and season upon the fiber and spinning quality of the samples studied and a consideration of the rank of the 16 varieties with respect to certain of the measurements made.

1/ The tests described in this report were conducted at College Station, Tex. in cooperation with the A. & M. College of Texas and the Bureau of Plant Industry, U. S. Department of Agriculture, by the staff of the Western Regional Spinning Laboratory, under the supervision of Roland L. Lee, Jr., and the general direction of Malcolm E. Campbell. The study constitutes a part of the work on the cotton quality and standardization research under the leadership of Robert W. Webb.

Much work has already been done with regard to the third objective--that of determining the relationships of the fiber properties to yarn quality. It is not planned to publish these findings, however, until the tests and analyses have been completed, since it is clear that any conclusions drawn now are subject to change when the complete data become available.

Spinning tests are time-consuming and expensive even in their simplest form. For these reasons it was not feasible to test the more than 5000 lots for which spinning test samples could have been made available. The program finally decided upon comprised 768 samples, representing two series for all 16 varieties grown at each of 8 locations for three successive years.

Tests for the first two of the three years have recently been completed and the results will now be considered.

THE SAMPLES

All of the samples used in these tests were grown and ginned by the Bureau of Plant Industry. The samples of seed cotton were shipped in sacks to Stoneville, Mississippi, where they were ginned on a small 16-saw gin without any preliminary cleaning. The fact that no cleaners were used probably accounts in part for the fact that the lint was on an average rather low in grade. The lint from the gin was packed into small bales of low density with the use of a hand press. The bales were then shipped to the laboratory of the Agricultural Marketing Service at College Station, Texas.

The bales weighed from 3 to somewhat more than 20 pounds each. While at least 5 pounds of lint was desired for a spinning test, it was not always possible to obtain this quantity, owing to adverse weather conditions at some stations where the cotton was grown.

The 16 varieties of cotton tested were as follows, in alphabetical order:

- Acala (Rogers)
- Arkansas 17
- Cleveland (Wannamaker)
- Cook 912
- Delta & Pine Land 11
- Dixie Triumph 759
- Farm Relief 2
- Half & Half
- Mexican (Big Boll)
- Missdel 4
- Qualla
- Rowden 2088
- Startex 619
- Stoneville 5
- Triumph 44 (Oklahoma)
- Wilds 5 (Coker)

Spinning test samples were obtained from material grown at the following locations:

Florence, S. C.
Stoneville, Miss.
Marianna (Upland Station), Ark.
Marianna (Delta Station), Ark.
Baton Rouge, La.
Stillwater, Okla.
College Station, Tex.
Lubbock, Tex.

At each location, each of the 16 varieties was grown in 8 series, numbered from 1 to 8, respectively, across the field. Series 1 was always on one side of the field, and Series 8, on the other, so that these two series represented the extreme positions in the field in every case. Since it was desired to learn something about the variation in quality within a field, but it was not feasible to test all of the samples grown, it was decided to include Series 1 and 8. In using material from these two series, it is probable that in most cases the extremes of quality for a given variety and location were included. That is, differences in soil and drainage are more likely to be significant between the extreme series than any other pair.

Such a plan resulted in 256 samples for spinning tests from each crop, or a total of 768 samples for the whole study. The results presented in this paper represent the first two crops (1935 and 1936), or a total of 512 samples of cotton.

TEST PROCEDURE

All fiber tests were carried out according to the standard procedure of the laboratories, under controlled atmospheric conditions (65 percent R. H. at 70 degrees F.) The fiber tests included length and length variability; strength as determined by the Chandler bundle method; fineness, in terms of weight per inch of fiber; and immaturity, or percentage (by number) of thin-walled fibers. A number of other tests, including nep counts of raw cotton and yarn, color measurements, X-ray structural analyses, fiber cross-section measurements, and several chemical tests have been or are being made on the same material, in the Washington laboratories. The results of these tests are not being presented here, but will be published elsewhere upon completion.

Classification according to grade, staple length, and character was made in Washington by the Appeal Board of Review Examiners. The samples used for this purpose were drawn at the time of ginning.

The spinning tests were performed with the technique developed in the laboratories of the Agricultural Marketing Service for use with small samples of cotton. Each sample was passed successively through the following textile machines:

Finisher picker (twice)
Card
Drawing frame (twice)
Slubber
Intermediate
Fine frame
Regular draft spinning frame
Heavy twister (two processes)

Quantitative measurements were made of the waste removed by the picker and card. Such manufacturing waste consists of both fiber and foreign matter. In order to obtain a measurement of the foreign matter alone, samples of raw cotton weighing 100 grams each were passed through a Shirley analyzer, which makes practically a complete separation of the fiber and foreign matter in a sample.

At the spinning frame, each sample was spun into three numbers of carded warp yarn, including 22s; a fine number, such as 44s, 50s or 60s, depending upon the staple length of the cotton; and an intermediate number, such as 28s, 36s or 44s. Also, each cotton was spun into 23s yarn, from which a supply of 23/5/3 carded tire cord of so-called standard construction was made.

Yarn twist multipliers used were those giving optimum skein strengths for the particular staple lengths, as determined by an empirical formula developed at the laboratories of the Service. An exception to this was the yarn spun for tire cord, in which a multiplier of 4 was used in all cases.

Automatically-controlled humidities and temperature were used in all card room and spinning room processes. The conditions were as follows: card room, 60 percent R. H. at 75 degrees F.; spinning room, 70 percent R. H. at 75 degrees F.

Laboratory tests on the yarns and cords were conducted in accordance with the standard methods adopted by the American Society for Testing Materials, whenever such standards applied. All of these tests were made under standard atmospheric conditions of 65 percent R. H. and 70 degrees F.

The tests on the yarns included the following: skein strength and size; single thread (Moscrop); moisture regain; and yarn appearance. Those on the tire cord included strength, elongation, yards per pound, gauge, and moisture determinations. Twist measurements on the ply, as well as the cable material, were made on each sample mainly as a control measure.

RESULTS OF TESTS

The results of the Regional Variety study lend themselves to two general methods of analysis, both of which have their advantages and disadvantages. The first is a routine statistical analysis, and the second may be termed a "graphical" analysis. By the latter is meant in this case the plotting of average values for the different measures, and a comparison of the various curves thus formed.

At the conclusion of all of the fiber and spinning tests, the results will be analyzed by both methods. For the purposes of this progress report, however, only the graphical method is being considered, except for an occasional reference to the order of rank of the different varieties or locations with respect to certain physical measurements.

In comparing averages for varieties and locations, it should be kept in mind that certain important variations which may be present can be entirely

obscured. In such instances an erroneous conclusion might be drawn if the observer is not on guard. An example will make this point clear: A severe drought at the Stillwater, Oklahoma station in 1936 had an adverse effect upon the quality of the lint. For one thing, all of the samples produced there were much shorter in staple than the corresponding samples grown elsewhere. Thus, in considering the average lengths for the different varieties in 1936, it might be observed that they were shorter than they were the previous year. However, if the values for the 1936 Stillwater cottons are omitted in calculating the averages, the results for the two years check very closely in most cases.

In the charts that follow, each plotted point is an average. The legend for each chart explains what values were averaged in each instance.

Where values for more than one type of measurement have been plotted on a single chart, as in figure 1, the scale is such that each vertical unit represents the same proportionate change in the value of the mean. In figure 1, for example, one inch of vertical distance on the scale for fiber weight per inch represents the same proportion of the mean weight as one inch on the scale of yarn strength does of the mean yarn strength. The same applies to the other measurements on this chart. (This does not mean, of course, that all of the fiber properties are of equal importance in determining the strength of the yarn. It has been demonstrated previously that certain properties are of greater importance than others as factors that influence yarn quality).

a) Fiber Properties and Yarn Strength

In figure 1 have been plotted, by variety, the weighted average skein strength of 22s yarn, and the fiber strength, length, fineness, and immaturity, for each of the two crop years. The varieties have been listed from left to right on the charts in the descending order of yarn strength for the 1935 crop samples. Each plotted point represents the average of both series 1 and 8 for all of the 8 locations.

One of the most obvious points brought out by this chart is the fact that all of the measurements on it -- yarn strength, and fiber strength, length, fineness, and maturity -- are quite definitely functions of the variety of cotton grown. There are individual exceptions, but in general the agreement between the two years is too close to be the result of chance. It is recognized , of course, and will be shown later that the place where the cotton is grown is also important, although naturally this is not brought out in figure 1, since the values for the different locations are averaged together. The importance of season, which is not so obvious in figure 1, will also be touched upon.

Except for one variety (Triumph 44) the 1935 yarns were a little stronger than the 1936 yarns. This difference, however, is due entirely to the poor quality of the drought-affected Stillwater cottons from the 1936 crop, as can be shown by calculating the averages omitting the Stillwater cottons. If this is done, the difference between the average strengths for the two years is less than 0.25 percent.

The range of average yarn strength in 1935, from that of Wilds 5 down to Half & Half, was 47 percent of the mean strength; in 1936, the range for the same two varieties, which were again the extremes, was 49.5 percent of the mean.

An examination of the curves for the four fiber properties as related to the yarn strength curves in figure 1 brings to light some interesting relationships. The data have been subjected to statistical analyses, but a discussion of the results is beyond the scope of this paper. The more important relationships are shown by the curves, it is believed.

Comparing the different varieties, it is seen that as yarn strengths decrease, on an average, fiber strengths decrease, lengths decrease, weights per inch increase, and percentages of thin-walled fibers decrease. There are, of course, individual exceptions to these trends, but in general they appear to hold for these tests.

It is obvious that some of the fiber properties vary in greater or less degree than the others, among the 16 varieties. This is brought out by a consideration of the coefficients of variation of the varieties with respect to the different measurements. These coefficients are as follows: yarn strength, 10.4%; Chandler bundle strength, 6.0%; upper quartile length, 10.2%; weight per inch, 12.7%; and percentage of thin-walled fibers, 15.2%. Thus, bundle strength shows the least variation, and percentage of thin-walled fibers, the greatest. Fiber length seems to vary at approximately the same rate as yarn strength, although it is seen that individual changes are not at the same rate or even in the same direction.

To summarize the comparison of the different varieties of this test with respect to fiber properties, it may be said that on an average stronger yarns are spun from cottons showing higher bundle strengths, longer lengths, lower weights per inch, and higher percentages of thin-walled fibers within the limits here involved.

The results of the two years may now be compared. As indicated, the slight decrease in average yarn strength for the 1936 varieties may be attributed to the drought-affected cottons at Stillwater. Otherwise, the strengths would have been about the same. Beginning at the bottom of the chart, it is noted that in general the 1936 cottons possessed higher percentages of thin-walled fibers, and were considerably lighter in fiber weight. The latter is doubtless the result of the former -- to a considerable extent, at least. It should be mentioned that these differences are due only in part to the 1936 Stillwater cottons. Upper quartile fiber length was clearly longer, on an average, in 1935; this, however, can be attributed almost entirely to the inclusion of the short Stillwater cottons of the 1936 crop in these averages. In 11 of the 16 varieties, the Chandler bundle strengths were higher in 1936 than in 1935. Strangely, this difference is likewise due in a large part to the Stillwater samples. As will be shown later, these drought-affected cottons possessed the highest fiber bundle strength in the lot.

At this point it may be well to consider the different varieties from the standpoint of the strength of the yarn spun from them. Table 1 shows the

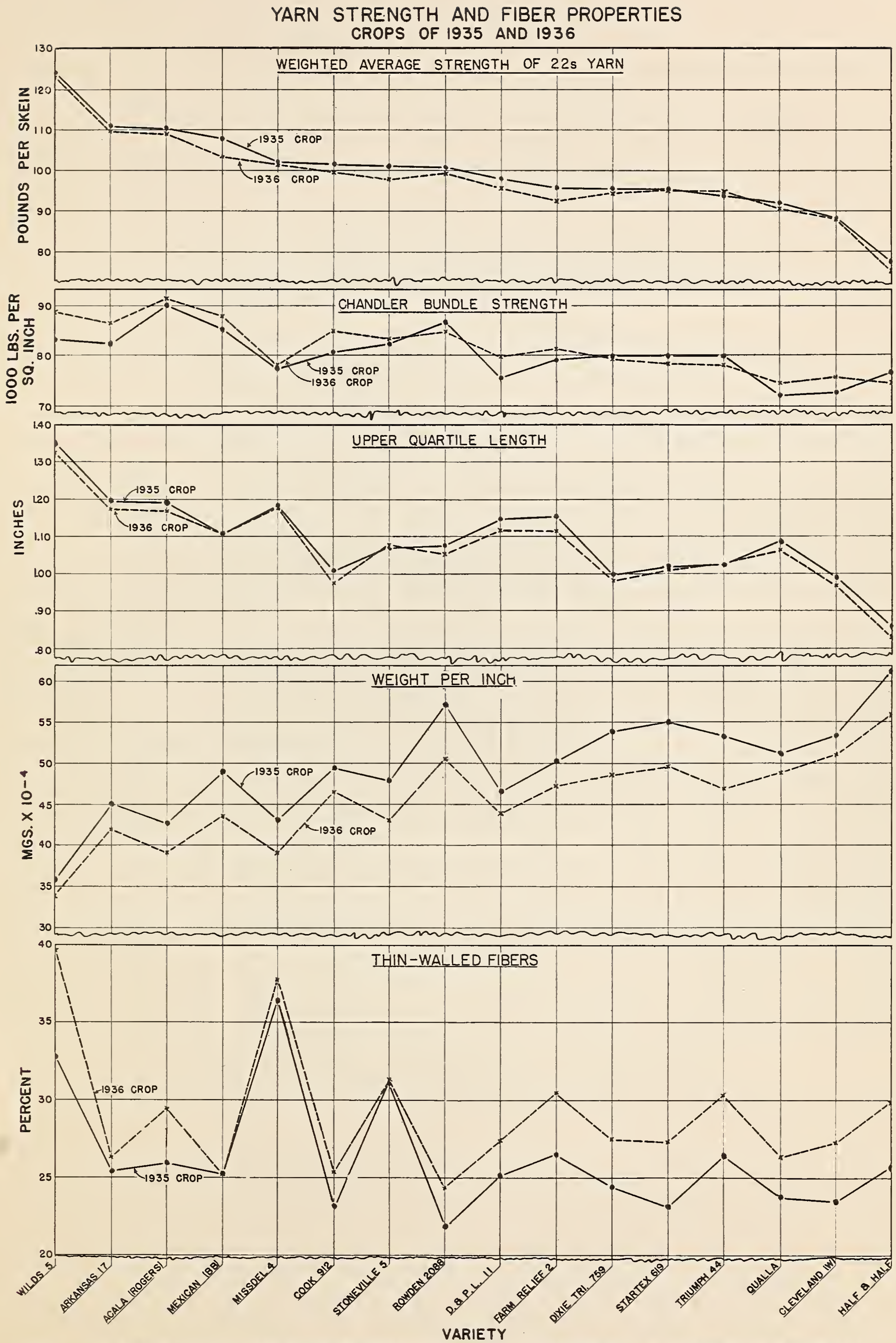

FIGURE 1.– YARN SKEIN STRENGTH AND FIBER PROPERTIES, CROPS OF 1935 AND 1936. EACH PLOTTED POINT IS THE AVERAGE FOR 2 SERIES AT EACH OF 8 LOCATIONS.

Table 1. - Rank of varieties with respect to weighted average skein strength of 22s yarn, by location and crop year 1/

Variety	Crop of 1935									Crop of 1936								
	Florence, S.C.	St'ville, Miss.	Mar. Upl., Ark.	Mar. Delta, Ark.	Baton R., La.	St'water, Okla.	Col. Sta. Tex.	Lubbock, Tex.	Average	Florence, S.C.	St'ville, Miss.	Mar. Upl., Ark.	Mar. Delta, Ark.	Baton R., La.	St'water, Okla.	Col. Sta., Tex.	Lubbock, Tex.	Average
Acala (Rogers)	2	3	2	2	8	3	2	2	3	2	2	3	3	5	1	4	4	3
Arkansas 17	3	2	3	3	3	2	4	3	2	3	3	2	2	1	5	2	2	2
Cleveland (W)	14	15	15	15	14	15	15	15	15	15	13	12	15	15	15	15	11	15
Cook 912	5	6	9	8	5	6	6	9	6	6	6	7	6	3	12	13	3	6
D. & P. L. 11	10	8	8	7	11	7	11	10	9	9	9	8	9	11	11	9	14	9
Dixie Tri. 759	9	9	14	11	9	12	14	11	11	11	15	11	11	8	14	12	5	12
Farm Relief 2	12	14	12	13	12	9	9	7	10	10	11	14	12	13	9	14	13	13
Half & Half	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Mexican (BB)	4	4	4	4	2	4	3	4	4	4	5	4	5	6	3	3	6	4
Missdel 4	7	7	5	5	7	5	7	8	5	5	4	6	4	4	13	5	8	5
Qualla	15	13	10	14	15	14	10	14	14	12	12	15	14	14	4	11	15	14
Rowden 2088	8	10	6	6	6	11	5	6	8	7	7	5	7	7	8	6	10	7
Startex 619	11	11	11	10	13	10	12	12	12	14	10	9	13	12	2	10	12	10
Stoneville 5	6	5	7	9	4	8	8	5	7	8	8	13	8	9	10	7	9	8
Triumph 44 (Okla).	13	12	13	12	10	13	13	13	13	13	14	10	10	10	6	8	7	11
Wilds 5	1	1	1	1	1	1	1	1	1	1	1	1	1	2	7	1	1	1

1/ In ranking the yarn strengths, the averages of Series 1 and 8 were used in each case.

rank of the different varieties at each station, and as averages, for each of the two years. With a few exceptions the varieties held their relative positions fairly well. In considering the ranking of the average strength for the two years, it is of interest to note that the first 6 varieties and the last 3 are the same for the two years. The remaining 7 varieties are for the most part bunched together, all being included in a range of about 7 pounds for each year.

At the Stillwater, Oklahoma station in 1936, where drought conditions prevailed during the season, the rank of the varieties with respect to yarn strength was upset in a rather curious way. For example, Wilds 5, Missdel 4 and Cook 912, which averaged 1st, 5th and 6th, respectively, for the year, fell to 7th, 13th, and 12th, respectively at Stillwater. It is to be noted that these cottons are usually grown in sections of the Cotton Belt where ample moisture is available.

On the other hand, Acala (Rogers), Startex 619, and Qualla, which averaged 3rd, 10th and 14th, respectively, for the year, are seen to fall in the 1st, 2nd, and 4th places at Stillwater in 1936. Acala (Rogers) seems to do well, as regards yarn strength, under both good and poor conditions. Startex 619 and Qualla, both of which are grown mainly in Texas, seemed to be able to withstand the drought conditions at Stillwater more readily than most of the other varieties.

In figure 2 have been plotted the average yarn strengths for the different varieties, and also the strengths as estimated from the particular staple lengths of the cottons. The latter values were determined with the use of an equation developed at the laboratories of the Agricultural Marketing Service from cottons tested over a period of years. It should be pointed out that the several hundred cottons from which the data were obtained represented a wide range of growth, harvesting, and ginning conditions, as well as many run-of-the-mine commercial cottons. Thus, in general, we should expect a somewhat lower average strength from these results than from a group of pure-bred varieties grown and ginned under reasonably good conditions.

Figure 2 shows that the relationships between actual and estimated yarn strengths are quite similar for the two years. It shows that the Wilds 5, Arkansas 17, Acala (Rogers), Mexican (BB), Cook 619, and Rowden 2088 varieties produced yarns with strengths considerably in excess of those expected from a consideration of their staple lengths alone. On the other hand, Farm Relief 2, Qualla, and Half & Half possessed yarn strengths below those expected. The reason for the relatively poor showing of Farm Relief 2 is not clear from an examination of figure 1. Although only about 4 cottons exceeded it in staple length, at least 9 cottons produced stronger yarns. A study of the three other fiber properties does not show a reason for this. Qualla was exceeded in length by about 8 varieties, but 13 varieties produced stronger yarn. Qualla is seen to be relatively weak as well as coarse fibered, which may be mainly responsible for its poor showing. Half & Half was much the shortest and coarsest of the cottons in the test, and at the same time was weak-fibered. Hence it is not surprising to find it at the bottom of the list in yarn strength.

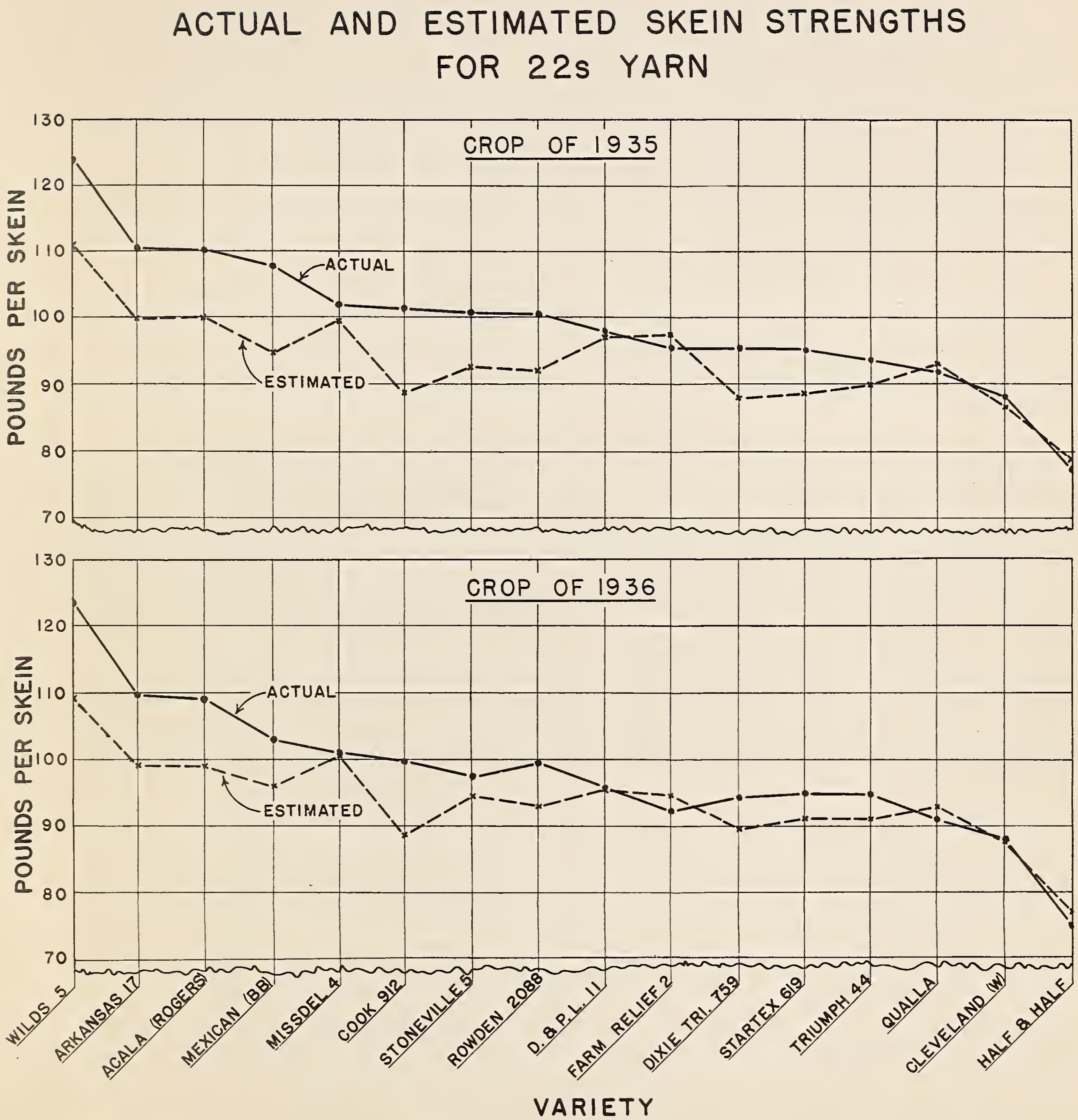

FIGURE 2.— ACTUAL AND ESTIMATED WEIGHTED AVERAGE SKEIN STRENGTHS FOR 22s YARN FOR TWO CROP YEARS. EACH PLOTTED POINT REPRESENTS THE AVERAGE OF 2 SERIES GROWN AT EACH OF 8 LOCATIONS. THE ESTIMATED VALUES HAVE BEEN CALCULATED ON THE BASIS OF STAPLE LENGTH.

In figure 3 the data have been averaged for all 16 varieties and plotted by location, following the same general method as used in figure 1. Yarn strengths were approximately the same in 1935 and 1936 at the following locations: Stoneville, Miss.; Marianna Delta Station, Ark., Baton Rouge, La.; and Lubbock, Texas. The 1936 yarns were much stronger at Florence, S. C., and much weaker at Marianna Upland Station, Ark., Stillwater, Okla., and College Station, Texas. An examination of the weather data will presumably be made by the Bureau of Plant Industry to explain these differences.

The increase in yarn strength at Florence in 1936 over 1935 was accompanied by an increase in fiber length and a decrease in fiber weight per inch and percentage of thin-walled fibers. Fiber strength remained unchanged.

At the Marianna Upland station, fiber length and strength remained essentially unchanged, but there was a noticeable increase in fiber immaturity, which was in turn reflected in a considerable decrease in fiber weight per inch. For the most part, the same changes were noted at College Station. In addition, there was a decrease in fiber length in 1936 at this station.

Accompanying the 15 percent decrease in yarn strength of the 1936 crop Stillwater cottons are an 8.5 percent decrease in fiber length, a 71 percent increase in thin-walled fibers, and a 21 percent decrease in fiber weight per inch. At the same time there was a slight increase in the strength of the fibers. While such an increase in fiber bundle strength under such conditions seems paradoxical, nevertheless it has been found to exist in a number of other cases of a somewhat similar nature.

Except for the 1936 Stillwater material, which was adversely affected by drought, the cottons from Baton Rouge, La., are consistently the poorest. These cottons are exceeded in length only by the Stoneville samples, and then only barely. They are, however, consistently the lowest in fiber strength as measured by the Chandler bundle method.

The curves in figure 3 show rather clearly that both fiber length and strength are closely associated with soil and weather conditions. To some extent, fiber weight per inch is, also, although the effect of season is quite apparent at three of the locations. Percentage of thin-walled fibers does not seem to be associated with location; for example, Stillwater showed the lowest percentage of the 8 locations in 1935, and the highest in 1936.

In connection with these remarks, it should be remembered that variety was a strong controlling factor for each of the fiber properties studied.

Figure 4 shows the average yarn strength for all varieties by location, and the estimated strength as based on staple length alone. Actual strength exceeded estimated strength at all points except at Florence, S. C., and Baton Rouge, La., in 1935, and Baton Rouge in 1936.

The rank of the 8 locations with respect to yarn strength and fiber length for the two crop years was as follows:

Location	Rank: Yarn strength 1/ 1935	1936	Fiber length 1935	1936
Florence, S. C.	7	3	7	3
Stoneville, Miss.	4	2	1	1
Marianna Upland, Ark.	1	4	5	5
Marianna Delta, Ark.	3	1	3	4
Baton Rouge, La.	8	7	2	2
Stillwater, Okla.	6	8	8	8
College Station, Tex.	2	5	4	6
Lubbock, Tex.	5	6	6	7

1/ Weighted average of 22s.

This table shows a greater degree of consistency in the length of fiber between the two years than in strength of yarn. Also, there was little relation between the ranking of the various locations for yarn strength and fiber length.

Figure 5 is included in this report mainly to demonstrate in as clear a way as possible the importance of variety as a factor in determining yarn strength. Some idea of the spread in strengths for the different stations may also be obtained from this chart. It is seen that the general shapes of the curves are the same for the different locations and for the two years. Likewise it may be noted by following the individual curves closely that the different locations maintain their respective positions rather well in the group of curves.

This chart brings out rather clearly the fact that the quality of cotton is influenced significantly by heredity and environment. If it were not for the fact that season also plays an important part in determining cotton quality, a manufacturer could maintain a constant level of quality simply by always using a particular variety grown at a particular place. However, as brought out by figure 3 and elsewhere, the effects of seasonal differences can be significant. This, of course, is something that most manufacturers know, as demonstrated by the number of questions which they ask each Fall in reference to the quality of the "new crop".

In this particular test only three seasons are represented, and as yet the complete results for only two of the seasons are available. It so happens that, for the most part, the yarn strength results for the 1935 and 1936 seasons were quite similar. Preliminary results on selected varieties grown in 1937, however, indicate that seasonal differences can assume much greater importance -- so great, in fact, that it is apparent that only by making tests for many seasons can a complete picture be obtained of the range of quality of a single variety of cotton.

The question of the variation for one variety between different field plots has not yet been touched upon. As previously indicated, the two samples tested for each variety at a given location represented the extreme positions of the field plots.

Yarn strength averages for the two opposite sides of the test fields showed only slight differences in most cases. At only two locations (Stoneville and Stillwater) in 1935 were the differences between Series 1 and 8

YARN STRENGTH AND FIBER PROPERTIES
CROP OF 1935 AND 1936

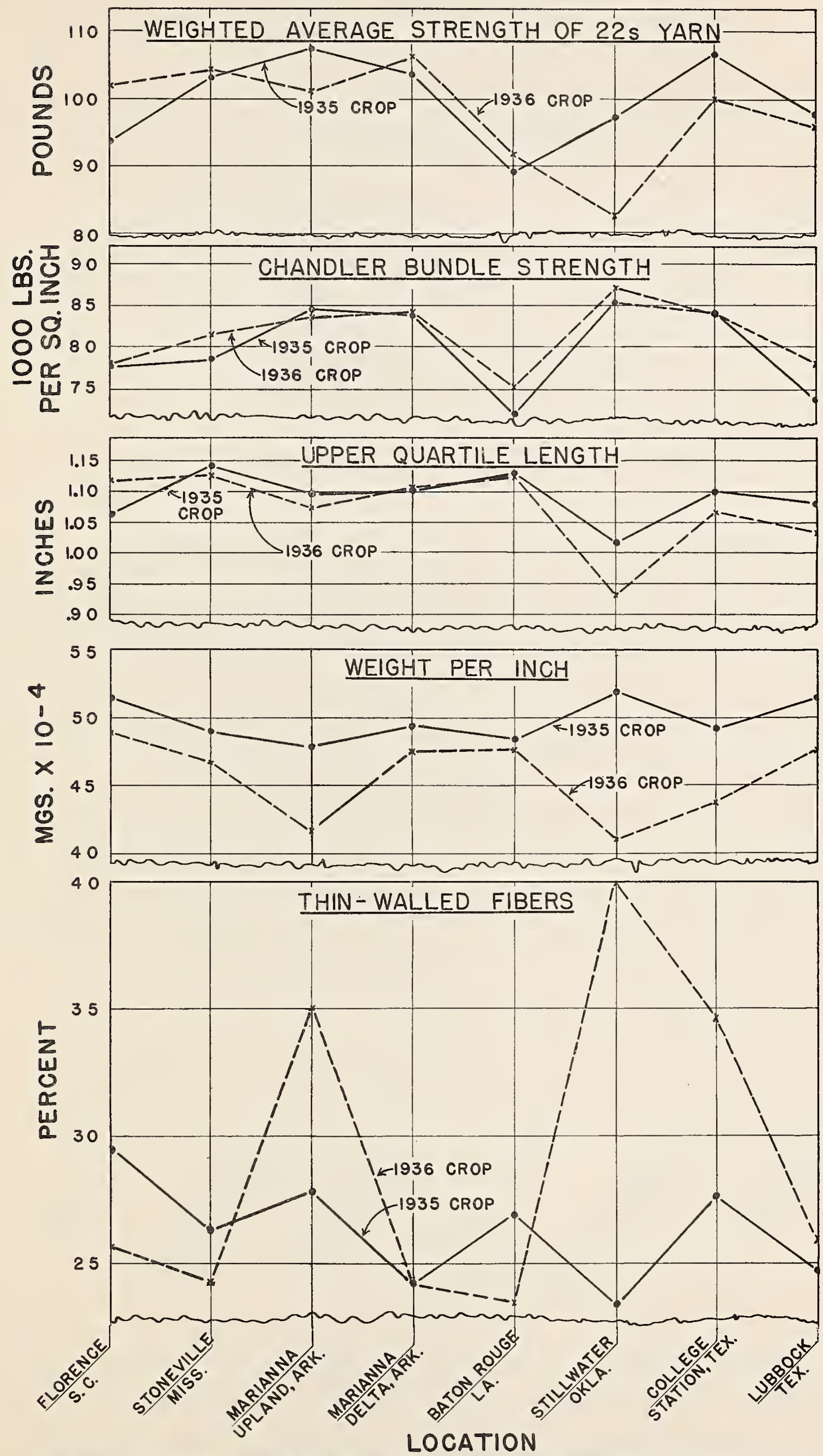

FIGURE 3.— YARN SKEIN STRENGTH AND FIBER PROPERTIES, CROPS OF 1935 AND 1936. EACH PLOTTED POINT IS THE AVERAGE FOR 2 SERIES FOR EACH OF 16 VARIETIES.

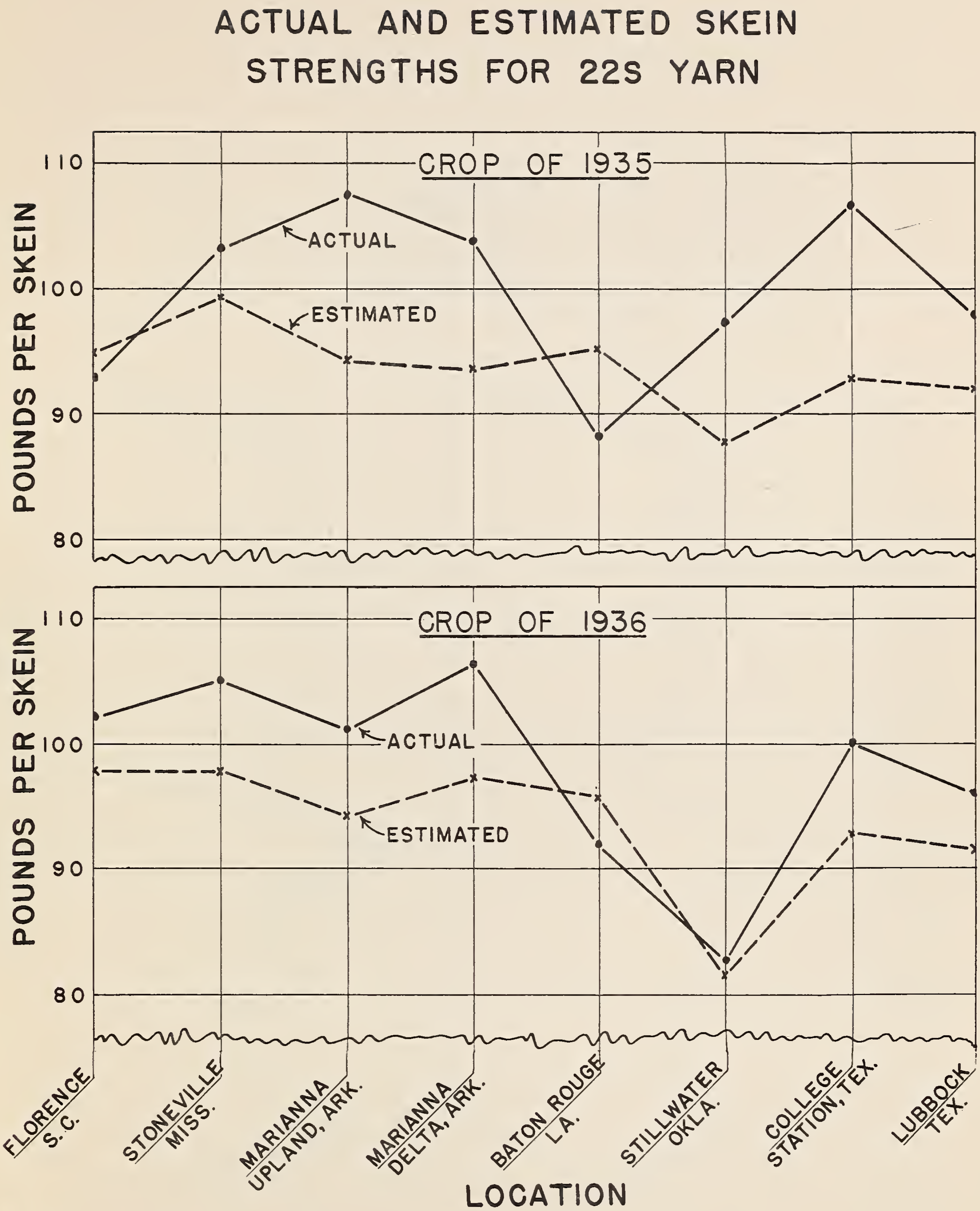

FIGURE 4.— ACTUAL AND ESTIMATED WEIGHTED AVERAGE SKEIN STRENGTHS FOR 22_S YARN FOR TWO CROP YEARS. EACH PLOTTED POINT REPRESENTS THE AVERAGE OF 2 SERIES FOR EACH OF 16 VARIETIES. THE ESTIMATED VALUES HAVE BEEN CALCULATED ON THE BASIS OF STAPLE LENGTH.

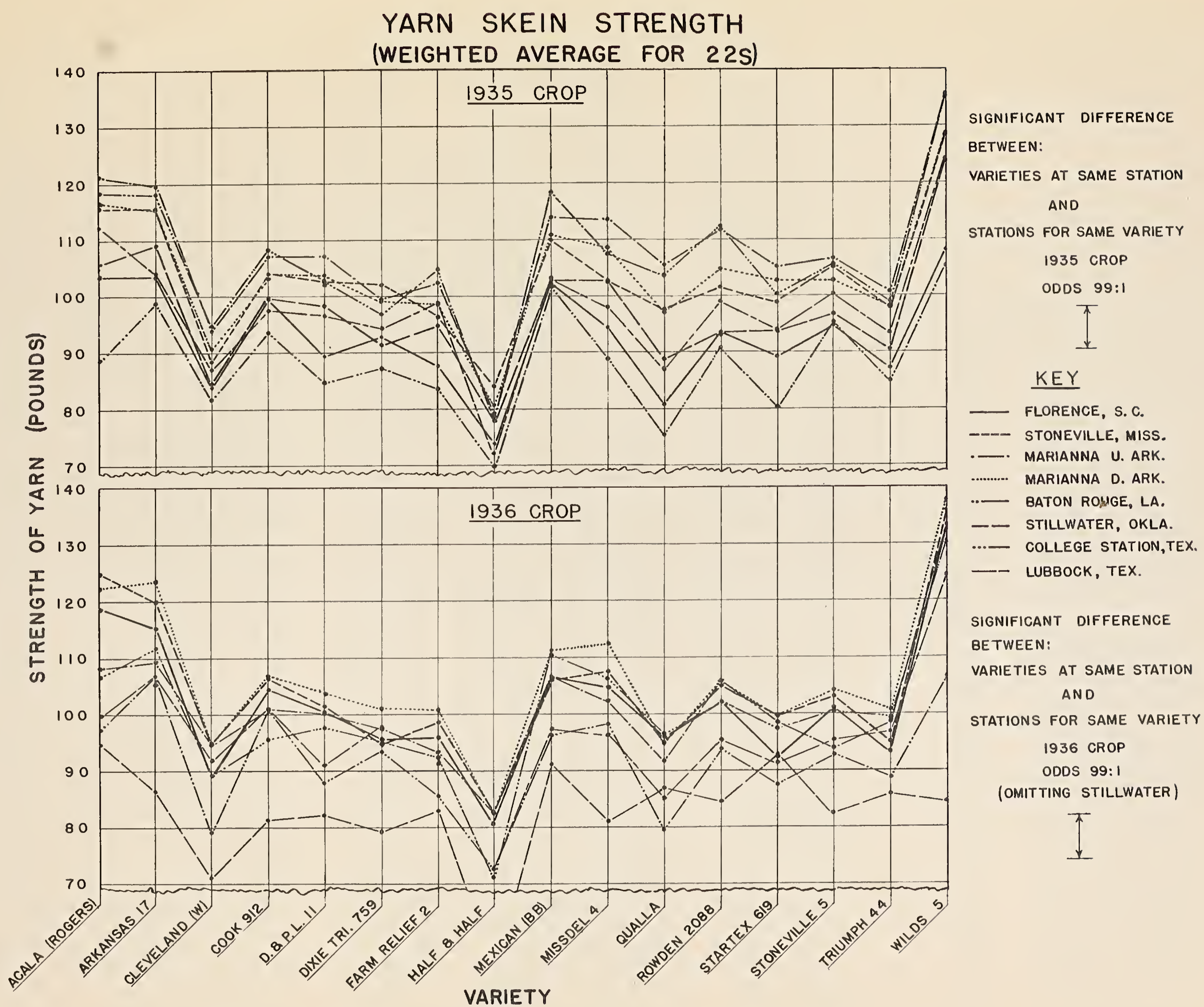

FIGURE 5.— WEIGHTED AVERAGE SKEIN STRENGTH OF 22S YARN, BY VARIETY AND LOCATION, CROPS OF 1935 AND 1936. EACH PLOTTED POINT IS THE AVERAGE OF 2 SERIES.

more than 3 percent. In 1936 the difference at Stoneville was only about 1 percent; no data are available for Stillwater in 1936, since only a small quantity of lint was available there and it was necessary to bulk the two series together for spinning.

The following figures will give some idea of the relative agreement between Series 1 and 8 for the individual cases. For 1935 and 1936, based on the mean for Series 1 and 8, the two series differed by from 0 to 2 percent in 36.6 percent of the pairs; between 2 and 4 percent, in 29.6 percent of the pairs; between 4 and 6 percent, in 21.2 percent of the pairs; between 6 and 8 percent, in 7.1 percent of the pairs; and over 8 percent, in 5.5 percent of the pairs.

In general the agreement between the two series was a little closer in 1936 than in 1935.

b) Tire Cord Strength

Good yarn strength is important to any cotton manufacturer, since it enables him to make goods of high quality and with a minimum cost. Strength of materials manufactured from cotton, however, is a matter of even greater importance in the fields of mechanical and industrial cords and fabrics. Among such materials is automobile tire cord.

It is known that the strength of single yarn does not always give an accurate index of the strength of a multiple cord made from the same cotton. This is presumably due to the fact that the difference in construction of single yarn and cord causes a difference in the manner in which the fibers are placed under stress; hence the various fiber properties may not bear the same relative importance in yarn and cord. In an effort to obtain more information on this subject than is now available, samples of 23/5/3 tire cord were manufactured from each cotton in this study, and tested.

The average strengths of tire cord made from the 16 varieties of cotton are shown in figure 6, together with the weighted average skein strengths of 22s yarn. The tire cord strengths have been corrected to standard weight and to a constant moisture regain.

The general trend of tire cord strengths is seen to be the same as that of the skein strengths of 22s yarn. (The correlation coefficient for the average skein strengths and the average cord strengths for the 16 varieties is found to be .90). There is less over-all variation in the cord strengths, however, as may be observed by noting the relatively smaller slope of the cord curves. This is further evidenced by the coefficients of variation, which are 10.4 percent for the skein strength and 5.9 percent for the cord strength.

There is some lack of agreement between the cord strengths for some of the varieties for the two successive years. These discrepancies are probably due to one of two things: some property of the fiber, or sampling and experimental errors. A comparison of the 1936 cord strength curves with those for the various fiber properties in figure 1 shows a slight indication

of sympathetic fluctuation in the cord strengths and percentages of thin-walled fibers. However, a more detailed analysis of the data will be needed before any satisfactory explanation can be reached.

c) Waste

The average percentage of manufacturing (picker and card) waste, together with the Shirley Analyzer waste and the grade of the cotton, have been plotted by variety for each crop year in figure 7. In plotting the grades, these factors have been given numerical designations in the usual manner (that is, Middling Fair is Grade 1 and Good Ordinary, Grade 9). The scales of grade and manufacturing waste are such that a vertical unit represents the same proportion of the mean value in each case.

It should be noted that the 1936 crop data are averages for 7 stations only, the results for Stillwater having been omitted. This was done because there was too little lint available for the Stillwater samples in most cases to make reliable waste determinations. On the few samples for which waste tests were made, the percentages were extremely high. Thus the inclusion of any waste data for the cottons from this station in 1936 would have distorted the curves and possibly led to erroneous conclusions.

The two curves representing the average grades of the cotton for the two years are seen to be quite similar in shape, indicating that grade is to some extent a function of variety. On an average the 1936 crop samples were lower in grade than the corresponding varieties in 1935, but too much significance should not be attached to this, since there were large differences between individual stations for the two years.

Manufacturing waste and Shirley analyzer waste are also seen to follow variety to a considerable extent. This, of course, is to be expected from a consideration of the grades. It may be seen that, while there is less variation in grade than there is for waste, nevertheless there is a considerable correlation between the values. The agreement is slightly better for the Shirley analyzer waste than for the manufacturing waste. This is because the Shirley analyzer removes only foreign matter, which is an element of grade, whereas the manufacturing waste also includes short fiber, which is not associated with grade.

A coefficient of correlation of plus .84 was found for the relationship of Shirley analyzer waste to manufacturing waste, indicating that this apparatus can be used to give a fairly good estimate of the amount of waste that will be taken out of a particular cotton in a mill. Studies beyond the scope of this paper are being made to increase, if possible, the accuracy of such estimations.

It is believed that a consideration of the physical characteristics of the plants of the different varieties of cotton may throw some light on the relative standing of the varieties with respect to grade and, to some extent, with respect to waste. This, however, is also a matter that is outside the scope of the present paper.

The four varieties yielding the lowest percentage of waste for the two years are seen to be Acala (Rogers), Qualla, Startex 619, and Rowden 2088. Among the most wasty are Cleveland (Wannamaker), Half & Half, Missdel 4, Cook 912 and Triumph 44.

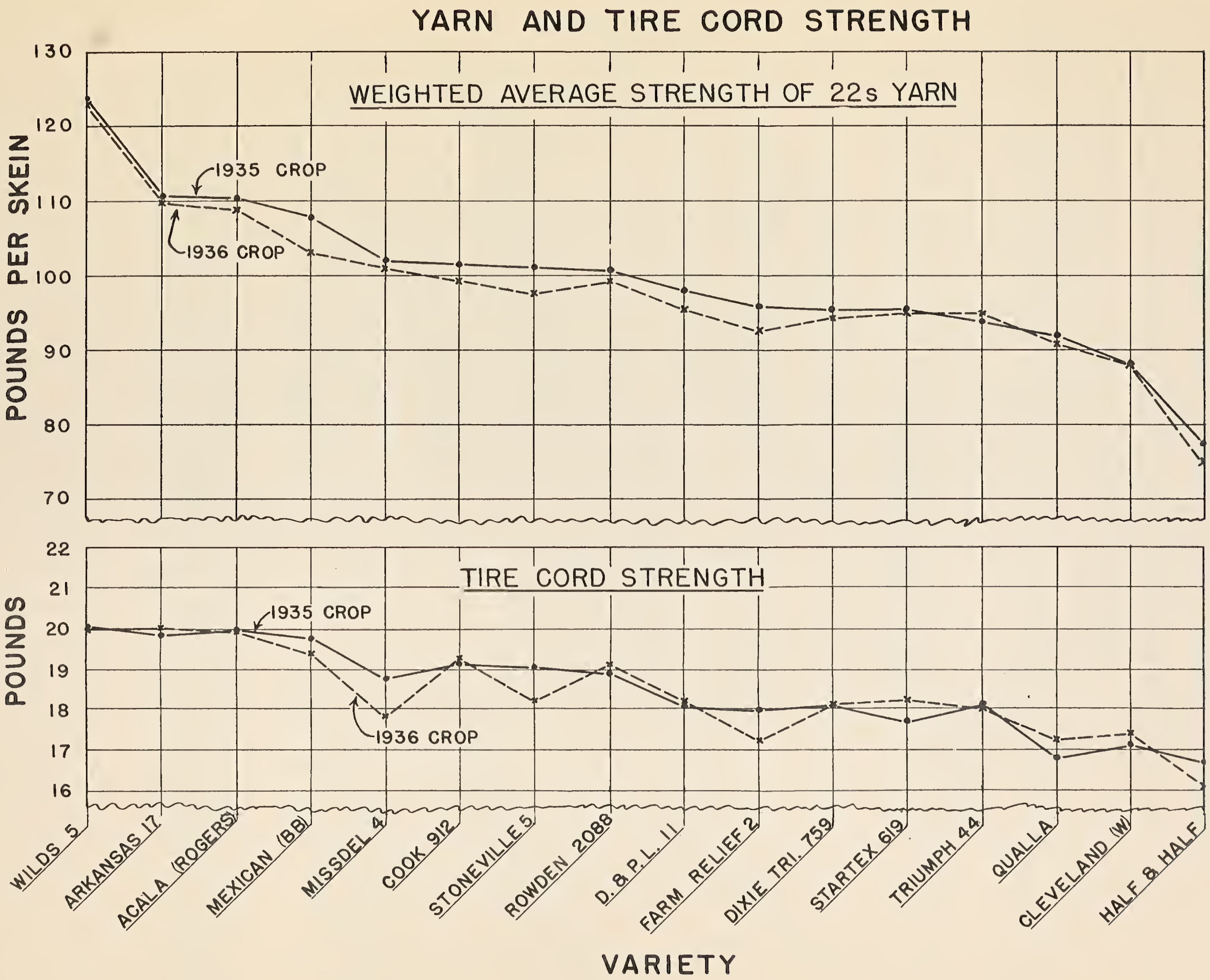

FIGURE 6.— SKEIN STRENGTH OF 22S YARN, AND STRENGTH OF 23/5/3 TIRE CORD, BY VARIETY, CROPS OF 1935 AND 1936. EACH PLOTTED POINT IS THE AVERAGE FOR 2 SERIES AT EACH OF 8 LOCATIONS.

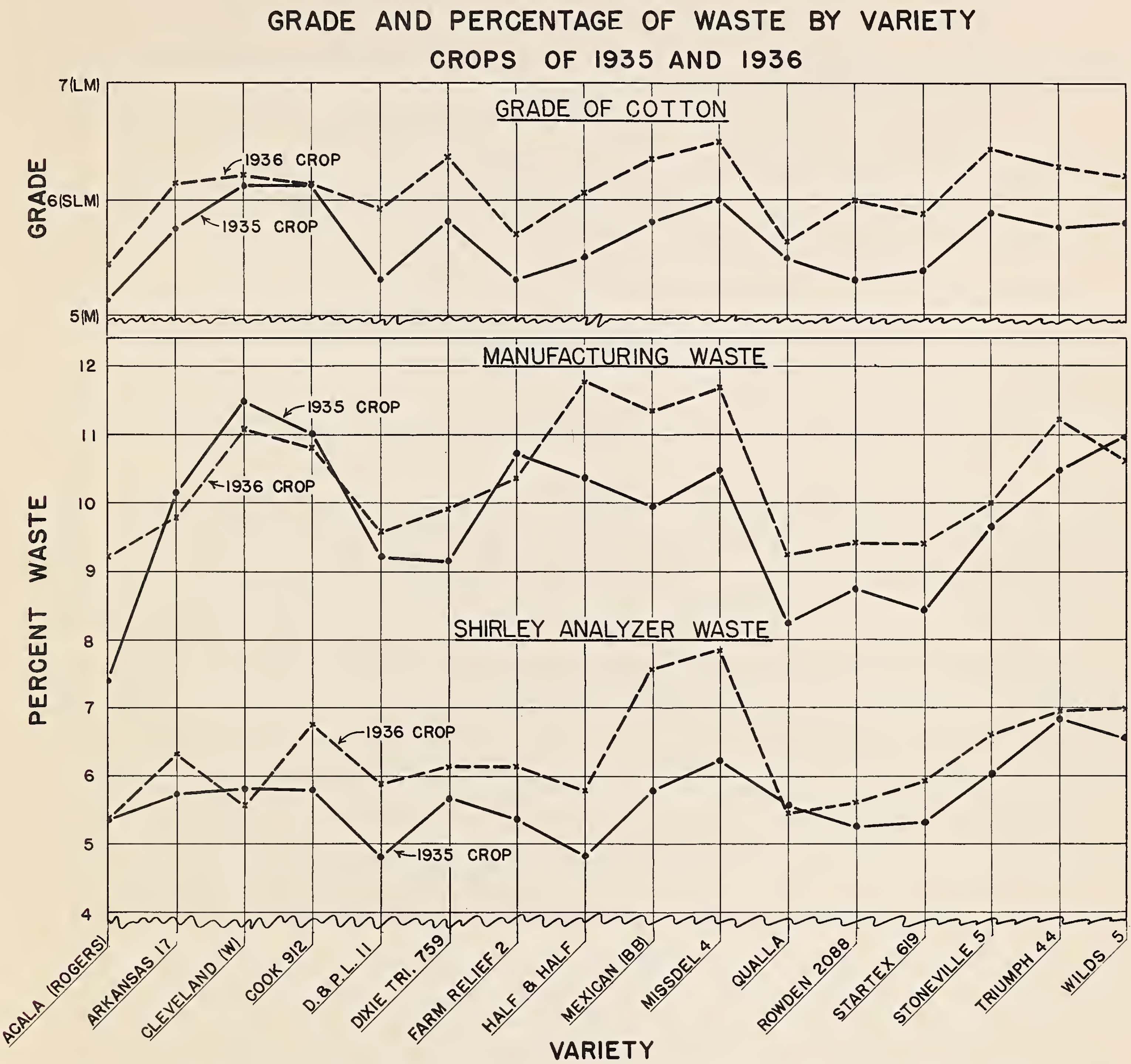

FIGURE 7.— GRADE OF COTTON, TOTAL PICKER AND CARD WASTE, AND SHIRLEY ANALYZER WASTE, BY VARIETY, CROPS OF 1935 AND 1936. EACH PLOTTED POINT REPRESENTS THE AVERAGE OF 2 SERIES GROWN AT 8 LOCATIONS IN 1935, AND AT 7 LOCATIONS IN 1936. NO DATA FOR STILLWATER, OKL. HAVE BEEN INCLUDED FOR THE 1936 CROP.

Figure 8 shows the average grade and waste data by location. It is seen at once that there is a much greater fluctuation among the locations than there was among the varieties (figure 7). In other words, the conditions surrounding the growth of the cotton constitute a more important factor in determining grade and waste than does the variety grown. This, of course, is merely a demonstration of a fact that is well-known by persons acquainted with the production of cotton.

The waste data for the 1936 Stillwater cottons are an average of only 5 varieties. As has been explained previously, there was insufficient material for more waste determinations among this group of samples. The few samples that were given waste tests showed such high percentages that it is probable that all of the varieties would have done so.

The very high waste percentages obtained for the College Station, Texas samples were due to the fact that all of this material contained large quantities of sand. The sand, which presumably was beaten into the cotton by the wind, was of a dark color and is reflected to some extent in the grade.

The cottons grown at Florence, S. C. and Stoneville, Miss., are the only ones yielding consistently the lowest percentages of picker and card waste. At the other stations there were evidently important weather differences between the two successive crop years during the time the cotton was open in the bolls.

Although the average agreement with regard to yarn strength between Series 1 and 8 at the various stations was fairly close, the differences in manufacturing waste are much greater. About 48 percent of the pairs differ by more than 10 percent, and about 21 percent differ by more than 20 percent in this respect. These facts possess some significance when it is remembered that there was a fairly close agreement between manufacturing waste and Shirley analyzer waste. That is, apparently the differences are due mainly to an uneven distribution of foreign matter in the cotton rather than to experimental errors at the spinning laboratory.

At most stations there is no consistent difference between Series 1 and 8. There are three exceptions, however. At Stoneville, Series 1 yielded more waste than Series 8 for 12 and 13 varieties, respectively, for the 1935 and 1936 crops. This suggests that there might have been a difference in the field that affected either the plant and foliage growth or the amount of dirt that came in contact with the open bolls. At the Marianna Upland Station, Series 2 yielded more waste in the case of 12 and 14 varieties, respectively, for 1935 and 1936. A similar investigation of local field conditions is also suggested in this case. At the Marianna Upland station there seems to have been a different effect for the two years. In 1935, all 16 of the varieties grown in Series 8 yielded more waste, whereas in the same field in 1936, 10 of the Series 1 samples were more wasty. Again, a check on local conditions for each year may explain the different results obtained.

The grades of the cottons are undoubtedly lower, and the waste percentages higher, than would normally be expected for the same varieties in commercial quantities. This is due primarily to the fact that the samples

were ginned on a small saw gin without the use of any cleaners. When ginned in large quantities on a full-sized gin much of the foreign matter remaining in these small samples would be removed, and the grade correspondingly improved. However, all of the samples in these tests were ginned in the same way, and the results are comparable among themselves.

d) Yarn Appearance

All of the cottons grown at Stillwater in 1936 produced extremely rough, uneven yarns because of the unusual character of the drought-affected cotton. Thus, in preparing figure 9, which shows the average yarn appearance grade by variety, an additional curve is presented, to permit a better comparison to be made between the two crop years. Even then, in 12 of the 16 cases the 1936 yarns were a little lower in grade.

A rather good correlation between the 1935 and 1936 crop curves is noted, showing that to a considerable extent the appearance of the yarn is influenced by the variety of cotton planted. Except for the Stillwater cottons in 1936, there is a smaller variation among the averages for locations (figure 10) than among varieties.

The "appearance" grade of yarn is determined by the number and size of the imperfections in it. These may consist of neps, seed coat fragments and other foreign matter, and thick-and-thin places caused by uneven drafting. Thus no one fiber property could be expected to control the appearance grade of the yarn. It is interesting to note, however, that there is a great similarity between the curves for yarn appearance in figure 10 and those for percentage of thin-walled fibers in figure 3.

Six of the varieties produced yarns averaging B plus or higher in grade for the two years (omitting the Stillwater cottons in 1936). These were: Half & Half, Startex 619, Dixie Triumph 759, Cleveland (Wannamaker), and Stoneville 5. Only two of these cottons, D. & P. L. 11 and Stoneville 5, averaged more than 15/16 inch in staple length. In the case of the following three varieties, the average grade was lower than B: Wilds 5, Acala (Rogers), and Farm Relief 2. The latter cotton was the only one of the three that averaged less than one inch in staple length.

From this it is seen that there is a tendency for the shorter cottons to produce smoother yarns. As a rule, shorter cottons are less neppy than longer ones, and, because of their larger fiber diameters as well as shorter lengths, draft more readily on the various machines. Thus it is not surprising that the better yarn appearance grades were produced by the shorter cottons in the test.

SUMMARY

Spinning and fiber studies are being made in the laboratories of the Agricultural Marketing Service on 768 samples of cotton, representing 2 series for each of 16 well-known and popular varieties, grown at 8 locations for 3 successive crop years, 1935-37. In this paper are presented the results of a preliminary analysis of the first two of the three years' tests, or 512 samples.

GRADE AND PERCENTAGE OF WASTE BY LOCATION
CROPS OF 1935 AND 1936

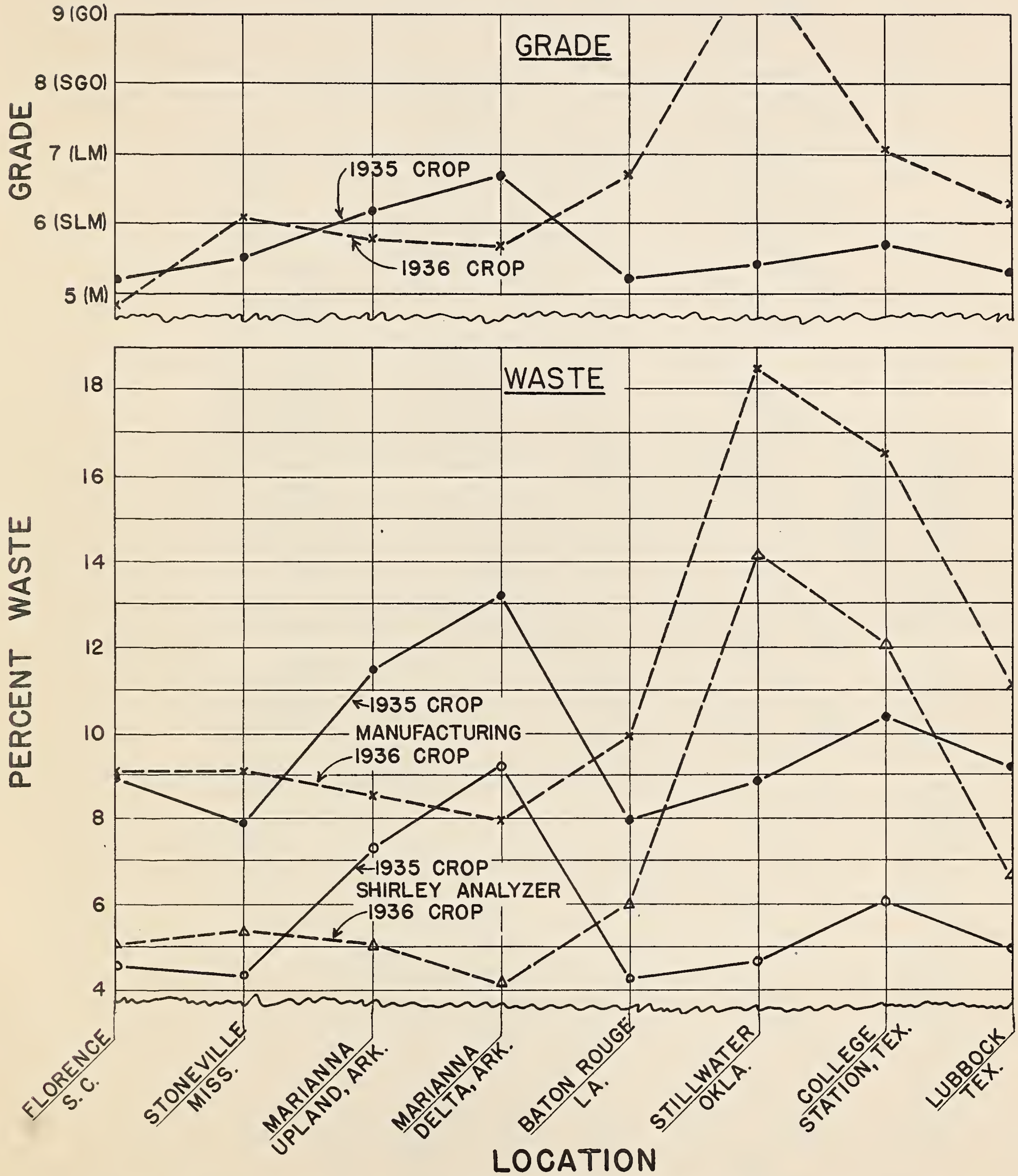

FIGURE 8.— GRADE OF COTTON, TOTAL PICKER AND CARD WASTE AND SHIRLEY ANALYZER WASTE, BY LOCATION. EACH PLOTTED POINT REPRESENTS THE AVERAGE OF 2 SERIES FOR EACH OF 16 VARIETIES.

APPEARANCE OF 22S YARN BY VARIETY
CROPS OF 1935 AND 1936

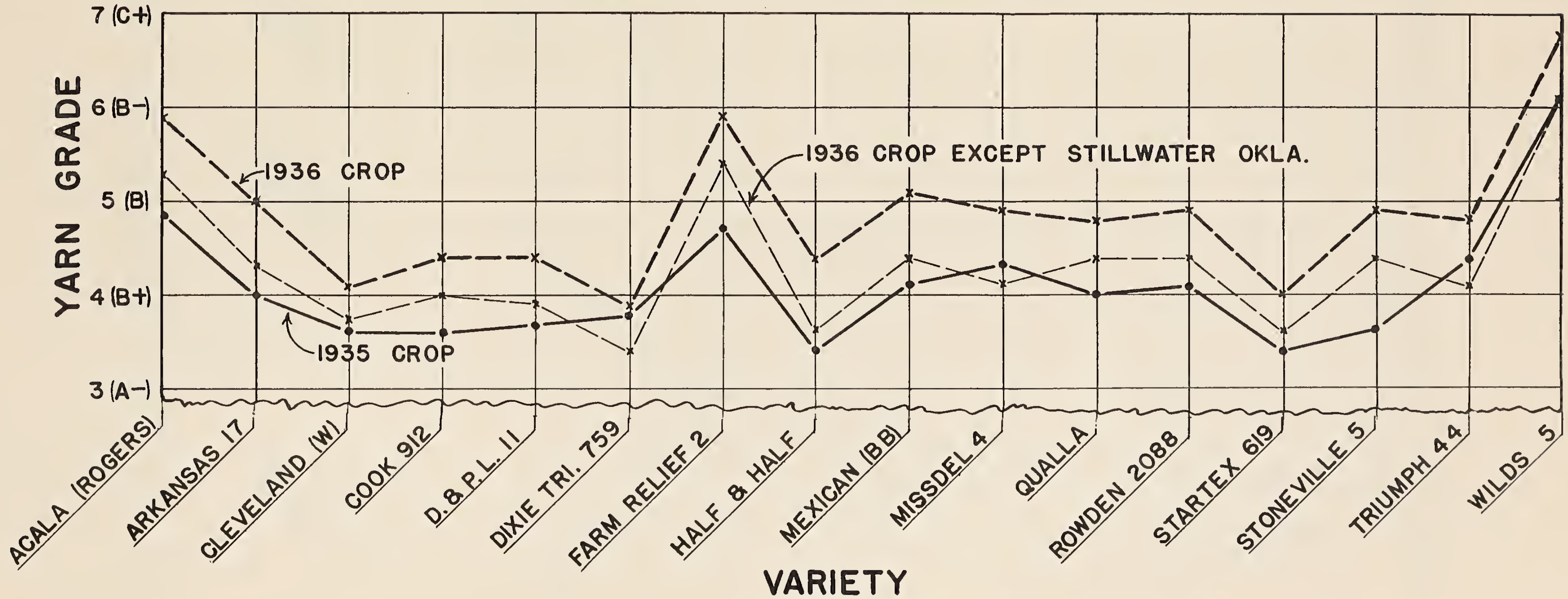

FIGURE 9.— APPEARANCE OF 22s YARN, BY VARIETY, CROPS OF 1935 AND 1936. EACH PLOTTED POINT IS THE AVERAGE FOR 2 SERIES AT EACH OF 8 LOCATIONS.

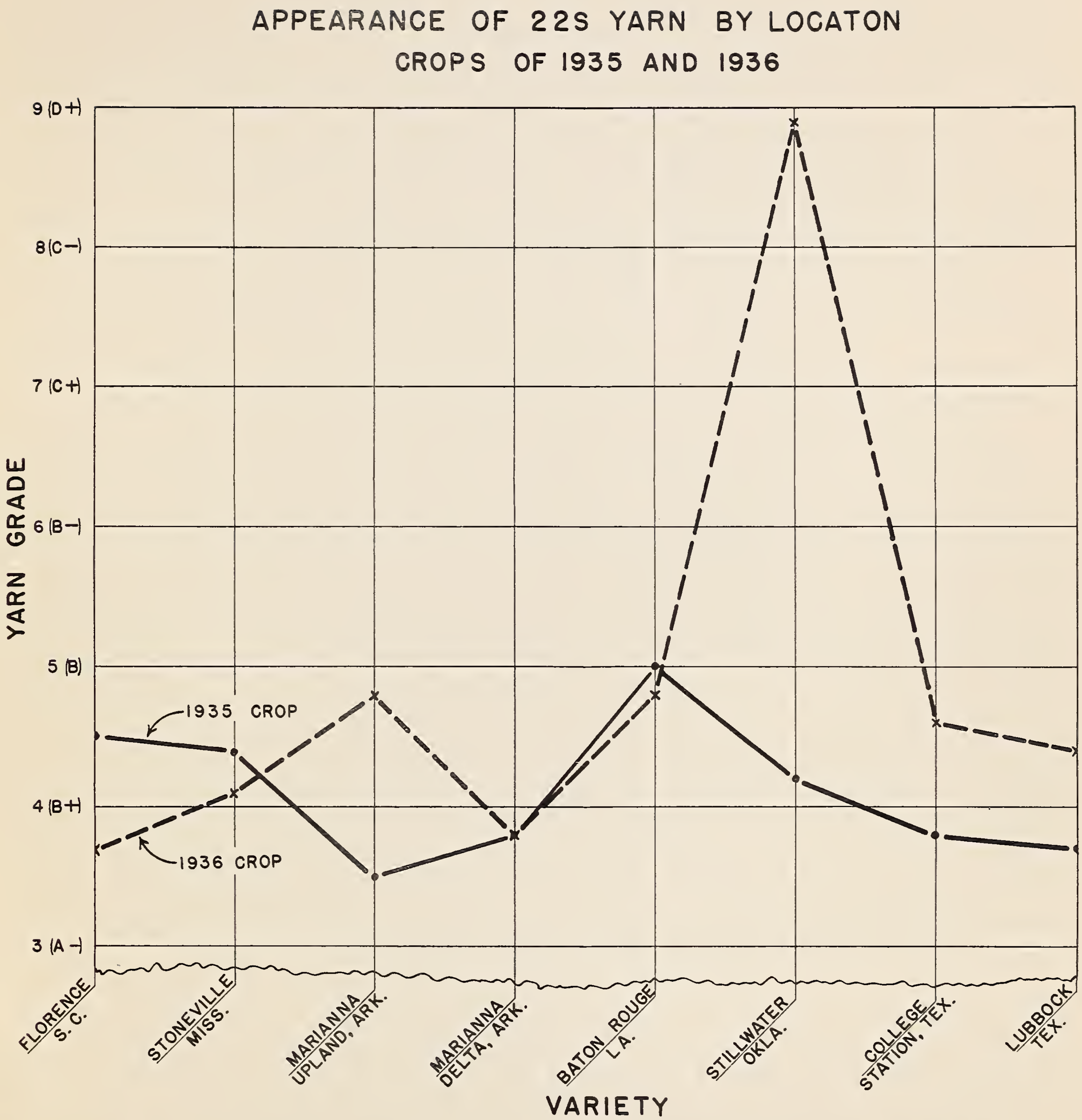

FIGURE 10.— APPEARANCE OF 22s YARN, BY LOCATION, CROPS OF 1935 AND 1936. EACH PLOTTED POINT IS THE AVERAGE FOR 2 SERIES FOR EACH OF 16 VARIETIES.

The discussion relates to the more obvious and important findings concerning the influence of variety, location, and season upon the fiber and spinning quality of the samples tested. The relationships among the varieties included in the first two years' work are not expected to be changed greatly by the inclusion of the third year's results. However, the effects of location apparently change materially from year to year, and it is clear that the results of many more than three years would be needed to give anything but a general idea of the effects of the infinite number of combinations of soil and weather found over the Cotton Belt.

Results of different measurements are considered in this paper as follows: fiber bundle strength, length, fineness, and immaturity; yarn strength and appearance, tire cord strength; and manufacturing waste, Shirley analyzer waste, and grade of cotton. At the conclusion of the tests, when the results for the three years are available, it is planned to publish a more thorough analysis of the data. Also, much other data remain to be analyzed and published, such as those for color, X-ray, chemical and other physical tests now being made in the Washington laboratories.

One of the most important points brought out by these tests is the fact that practically every property measured is, to a relatively large extent, clearly a function of the variety of cotton planted. It has been known in a general way, of course, that such factors as the staple length of cotton and the strength of yarn spun from it were influenced by variety; and some observations have indicated that fiber strength and fineness also are associated with factors of inheritance and genetics. As far as is known, however, these tests demonstrate for the first time that such properties as percentage of thin-walled fibers, the appearance of the yarns, the amount of waste, and even the grade of the cotton are quite definitely influenced by variety.

Some of the fiber properties measured, as length and bundle strength, are also affected to a considerable degree by the place where the cotton is grown which, of course, involves a combination of place and seasonal effects. Fiber fineness and strength of related yarn appear to behave the same way to some extent, although extreme seasonal differences can affect these relationships significantly. The relationships between the findings for the different stations as regards such properties as percentage of thin-walled fibers, the appearance of yarn, and the grade of the cotton and quantity of manufacturing waste, are definitely upset by seasonal differences.

Differences in fiber properties and yarn strength between corresponding varieties for the respective series were in general quite small, and the agreement may be considered good. This was not true of the manufacturing waste percentages, however, which differed rather widely. A high correlation between manufacturing waste and Shirley analyzer waste suggests that these differences actually occurred in the ginned lint -- that is, they were not due to experimental errors at the spinning laboratory. The results indicate that local place or seasonal conditions, or both, at three of the stations, may have caused the differences in waste content, and a further study of these conditions is planned.

It is believed that careful statistical analyses at the conclusion of the three years' tests will confirm the general findings of the graphical analyses reported here.

When all of the data and statistical analyses become available, it is expected that they will bring to light a number of other significant relationships which are not apparent at the present stage of the work. These should be of importance to practical problems connected with American cotton and the breeding, production and improvement, on the one hand, to classification, standardization, marketing and utilization, on the other.